Chen, Y., and Li, W.X. "The Effect of Passive Smoking on Children's Pulmonary Function in Shanghai" Am J Public Health 76: 515-518, 1986.

The authors studied the relationship between passive smoking and pulmonary function of 571 children in Shanghai, People's Republic of China. The children studied ranged in age from 8 to 16 years. Questionnaires were completed by the children's parents, and lung function tests were administered to the children. Paternal smoking status during the child's lifetime was linearly related to a decrease in the percent predicted values of FEV1.0, MMEF, and FEF62.5-87.9 in all subjects; in school girls, paternal smoking accounted for 0.5 percent, 1.2 percent, and 1.6 percent of the total variation for these lung function parameters respectively. The trend was reportedly less marked in boys. Other environmental factors considered in this study included educational level of the father, the use of coal or gas for cooking, and the presence of patients with chronic respiratory diseases in the family. These other factors reportedly had "no important role on the children's pulmonary function."

2023383230

The Effect of Passive Smoking on Children's Pulmonary Function in Shanghai

YUE CHEN, BM, AND WAN-XIAN LI, MD

Abstract: We report the findings of a cross-sectional study of the relationship between passive smoking and pulmonary function of children in Shanghai, People's Republic of China. The 571 study subjects included 303 males and 268 females, ranging in age from 8 to 16 years, from a primary school and a secondary school at Xu-Hui District. Lung function tests were performed at the schools, and questionnaires were completed by parents. The father's cigarette smoking status during child's lifetime was linearly related to a decrease in the per cent predicted values of $FEV_{1.0}$, MMEF and $FEF_{62.5-87.5\%}$ in total subjects; in school-girls, father's smoking status accounted for 0.5 per cent, 1.2 per cent, and 1.6 per cent of the total variation, respectively; the trend was less marked in boys. Other environmental factors considered in this study, i.e., educational level of the father, the use of coal or gas for cooking, the presence of patients with chronic respiratory diseases in the family, etc., did not seem to have any important role on the children's pulmonary function. (*Am J Public Health* 1986; 76:515–518.)

Introduction

It has been suggested that the smoking habits of individuals in a household adversely affect the health of non-smoking family members through exposure to tobacco combustion products in the indoor environment.[1,2] Sidestream smoke, which rises from the burning end of the cigarette and produces approximately 70 per cent of the air pollution due to tobacco smoke in a room, contains even greater concentration of some toxic compounds than mainstream smoke exhaled by smokers.[3-5] Children of smoking parents have been observed to have reduced pulmonary function.[6-10] A dose-response relationship has been found in some studies,[6-8] but other studies failed to find an association between children's pulmonary function and the smoking habits of their parents.[11-14] Methodological and data processing differences may be responsible for these conflicting results.

We report the findings of a cross-sectional investigation in Shanghai using stepwise regression and other methods in data analysis.

Methods

Subjects

A total of 571 children (303 males and 268 females) 8 to 16 years of age from a primary school and a middle school at Xu-Hui District in Shanghai participated in this cross-sectional study in June 1984. The residential area of sample selection is so small that it is reasonable to consider the level of outdoor urban air pollution to be the same for all residents.*

Pulmonary Function Test

Lung function tests of the children were performed at schools using two 8-liter water-filled recording spirometers. The children did not wear nose clips, and the tests were performed in a sitting position. Good understanding and cooperation were usually obtained. Each child was tested until three acceptable curves were obtained. The two best forced vital capacity's (FVCs) of the three acceptable curves should not vary by more than ±10 per cent in reading or ±100 ml, whichever is greater. The single best curve, which has maximal forced expiratory volume in one second ($FEV_{1.0}$), was used in the analysis. FVC, $FEV_{1.0}$, maximal midexpiratory flow (MMEF), and forced expiratory flow from 62.5 per cent to 75.5 per cent of FVC ($FEF_{62.5-87.5\%}$) were read from this best tracing. Values were corrected to body temperature and pressure saturated with water vapor (BTPS). Each child was free from any cough, cold, or sore throat at the time of testings. Standing height, weight, and chest measurement (CM) by the end of expiration were measured at the same time.

Questionnaire Administration

The children's parents completed a questionnaire providing information on their smoking habits and those of other household members over the child's lifetime, on demographic characteristics, medical history, the use of coal or gas for cooking, average household residential area per capita, and father's education.

Smoking habits of the children were obtained from another questionnaire, completed in the classroom and returned to the investigator at once. Children who reported smoking one or more cigarettes per week were rare and were excluded from analysis, as were children with a history of asthma or congenital heart disease.

Data Analysis

Stepwise regression analysis was applied to a model including 12 terms, spelled out in the Appendix. Spirometric indexes (FVC, $FEV_{1.0}$, MMEF, and $FEF_{62.5-87.5\%}$) were analyzed separately for male and female. F value to enter and remove was fixed to the level of $\alpha = 0.05$. Appropriate transformations and a parametric test of normality[15] for the original data of spirometric indexes were done (data available on request to author).

Results

Table 1 displays the results of the stepwise analysis. The transformed FVC is closely related to age, standing height and chest measurement in males, and with standing height and chest measurement in female, accounting for 79 per cent and 68 per cent of the total variation, respectively; there are no associations with any environmental factors in either sex at the level of the fixed F value chosen in advance. Because flow depends on volume,[14] and because the relationship between father's smoking status and the FVC of children did not reach the 0.05 level, the data were also controlled for

*The annual average mediums of SO_2, NO_2, Pb, and F in the Xu-Hui District are 0.07, 0.02, 0.000428, and 0.24 mg/m³, respectively. The maxima in 1984 were 0.59, 0.09, 0.00907 and 0.40 mg/m³.

From the Department of Epidemiology, Shanghai First Medical College, School of Public Health. Address reprint requests to Yue Chen, BM, Department of Epidemiology, School of Public Health, Shanghai First Medical College, Shanghai 200032, People's Republic of China. This paper, submitted to the Journal May 28, 1985, was revised and accepted for publication October 18, 1985.

TABLE 1—Analysis for Transformed FVC

Stepwise Regression Analysis	Factors Selected				
	Male			Female	
	Age	Ht.	CM	Ht.	CM
b*	0.0078	0.0039	0.0035	0.0051	0.0055
S_b*	0.0025	0.0005	0.0007	0.0006	0.0009
R†	0.8871			0.8269	

*Partial regression coefficient.
*Standard error of partial regression.
†Multiple correlation coefficient.

FVC when the three other spirometric indexes were analyzed in order to compensate for differences in lung size.

Table 2 shows the results of the transformed $FEV_{1.0}$, MMEF, and $FEF_{62.5-87.5\%}$ regressions for males. In addition to the physical characteristics and FVC, father's smoking quantity (cigarettes/day × years) during the children's lifetime accounted for 0.1 per cent, 0.5 per cent, and 0.8 per cent of the total variation separately. The remaining environmental factors did not show significant effects on boys' lung function. The trend was more marked in females. For a girl aged 12 years, of average height, weight, and chest measurement (147 cm, 37 kg, 68 cm), the predicted $FEV_{1.0}$, MMEF, and $FEF_{62.5-87.5\%}$ were 1.78 liter, 2.24 liter/sec, and 1.32 liter/sec if the father smoked 10 cigarettes a day for 10 years during the girl's lifetime, and 1.84 liter, 2.38 liter/sec and 1.45 liter/sec if he did not smoke. In addition, the use of gas for cooking in family showed a negative relationship with transformed $FEF_{62.5-87.5}$ per cent of females.

In order to compare and clarify the results, the per cent of predicted values of $FEV_{1.0}$, MMEF, and $FEF_{62.5-87.5\ \text{per cent}}$ of the two sexes were calculated. The prediction equations for lung function of each sex were derived from the data of the total survey population. From these equations, the proportion of the total variation, which is explained by age, height, weight, chest measurement and FVC, is determined. The regressions for the per cent of predicted values of $FEV_{1.0}$, MMEF, and $FEF_{62.5-87.5\%}$ plotted as functions of father's smoking quantity in child's lifetime are shown in Figure 1. The slope of the lines are not the same. The lines of $FEF_{62.5-87.5\%}$ decrease more rapidly than the others.

The average residential area per capita was 5.3 m^2 for nonsmoking father families and 5.1 m^2 for smoking father families; the average number of persons per family was 4.2.

Discussion

Two earlier findings reported by Tager and his associates[6] and by Weize and his coworkers[7] have shown results similar to ours: the greater the number of smokers at home, the lower the MMEF value of the child, although these studies lacked quantitative estimates of lifetime passive smoke exposure. In another study, Hasselblat[8] found a significant correlation between the amount smoked by the mother and $FEV_{0.75}$ value of her child, but the amount smoked by father was not related to the child's pulmonary function test. The authors felt that smoking information of the mother might be more accurate than that of the father and that the mother might spend more time with her child.[8] In Shanghai, cigarette smoking is very rare among young women in general, and no mothers in our study reported that they smoked. Other household smokers could be sources of passive smoking but there were very few identified in our study. The smoking rate of other persons in families was 6.0 per cent, while the father's smoking rate was 39.2 per cent.

The hazardous effect of cigarette smoking on the health of passive smokers depends not only on the number of cigarettes smoked in the families but also on ventilation and the volume of enclosed space.[7] Because living space in the urban area of Shanghai is so small, the actual amount of indoor exposure to children may be substantially greater than in many other areas of the world. Although exposure may have been more intense, its effect could not be measured because virtually all children lived in crowded quarters. It has been reported that the ventilation rates in warm areas of the US are higher and the smoke may be more easily diluted by the air than in generally colder areas.[13] This was another modifying factor that we were unable to measure.

Determination of the rate at which air flows out of the lungs during FVC provides important information about the resistance to airflow during forced expiration.[17] Our results showed an obstructive pattern[16] and suggested that exposure to cigarette smoking may have more obstructive than restrictive effect on the lungs as Tager, *et al*,[7] and Weiss *et al*,[6] have reported.

Our data show that the effect of passive smoking is greater in schoolgirls than in boys. Schoolboys may spend more time outdoors than schoolgirls, and thus be less exposed to indoor smoking.

There were no important effects on the lung function of children of the other environmental factors considered in our

TABLE 2—Analysis for Transformed $FEV_{1.0}$, MMEF, and $FEF_{62.5-87.5\%}$ in Male Children

Stepwise Regression Analysis	Factors Selected													
	$FEV_{1.0}$				MMEF			$FEF_{62.5-87.5\%}$						
	Ht.	ESF	SQF	FVC	Ht.	SQF	FVC	Age	Ht.	Wt.	CM	SQF	SQO	FVC
b	.0012	.0066	−.0012	.1152	.0024	−.0059	.0996	.0125	.0096	−.0090	.0069	−.0096	.0133	.0644
S_b	.0004	.0043	.0015	.0071	.0009	.0035	.0170	.0082	.0020	.0034	.0037	.0050	.0084	.0259
R	.8215				.7117			.6891						

ESF = Educational Status of Father.
SQF = Smoking Quantity of Father.
FVC = Forced Vital Capacity.
CM = Chest Measurement.
SQO = Smoking Quantity of Others.

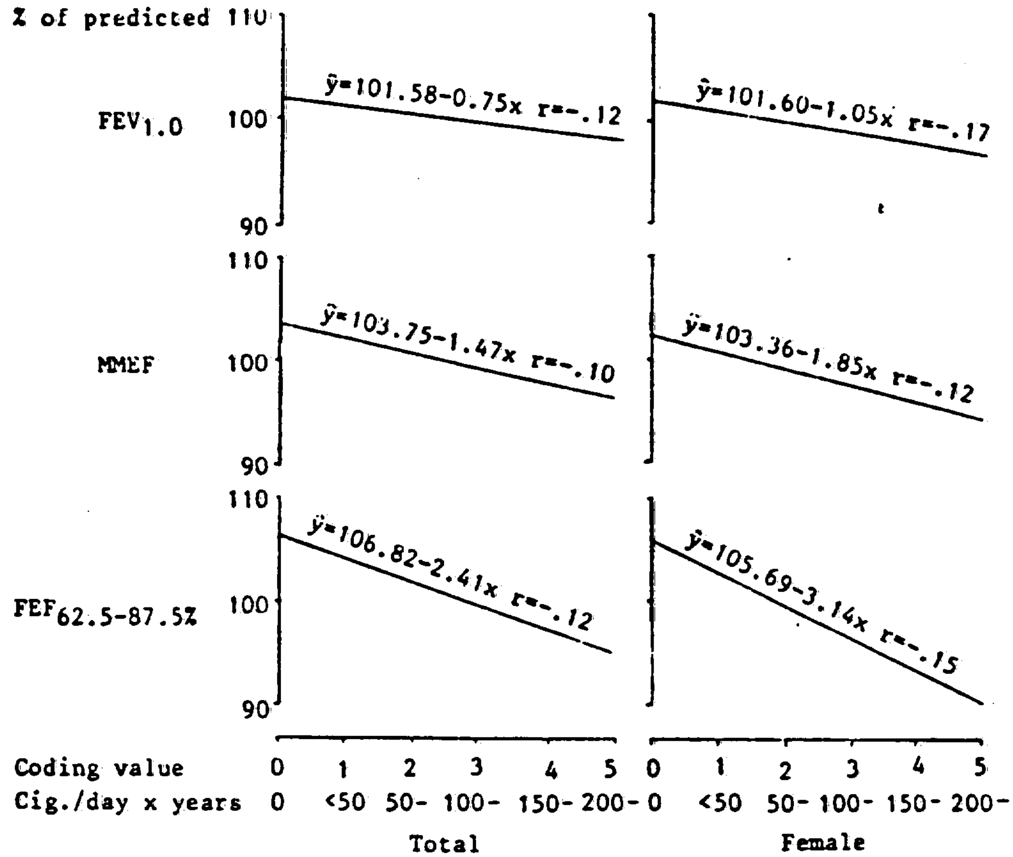

FIGURE 1—Adverse Effect of Father Smoking on Lung Function of Children.

study. The slight difference of per cent predicted values of $FEV_{1.0}$, MMEF, and $FEF_{62.5-87.5\%}$ among different groups of girls classified according to father's educational level may denote that the smoking rate was lower for men with university level education (27.9 per cent) than those with secondary or primary schooling (44.7 per cent and 57.1 per cent, respectively). When we adjusted for father's education, the effects of passive smoking were still evident.

Several studies have reported that using coal for cooking is more harmful to children's health than using gas.[19] In this survey, only a small number of households (14.5 per cent) used the coal-fueled stove at home, and the influence of coal could not be detected.

It has also been suggested that the presence of respiratory symptoms in children is not only associated with parental smoking, but also with respiratory symptoms among parents.[14,20] In our study, the presence of patients with chronic respiratory diseases in the family did not affect the lung function of children.

It has been reported that tobacco smoke can be a significant source of atmospheric pollution in enclosed areas.[21] This cross-sectional survey offers new evidence that

TABLE 3—Analysis for Transformed $FEV_{1.0}$, MMEF, and $FEF_{62.5-87.5\%}$ in Female Children

Stepwise Regression Analysis	Factors Selected											
	$FEV_{1.0}$				MMEF				$FEF_{62.5-87.5\%}$			
	Ht.	Wt.	SOF	FVC	Ht.	Wt.	SOF	FVC	Ht.	SOF	Gas	FVC
b	.0012	−.0007	−.0021	.0714	.0086	−.0055	−.0157	.2077	.0073	−.0193	−.0668	.1168
S_b	.0002	.0003	.0008	.0039	.0024	.0026	.0078	.0393	.0018	.0075	.0357	.0367
R	.9125				.5626				.5966			

See Table 2 for acronyms.

2023383233

passive smoking may constitute a real threat to the health of many urban children. Passive smoking is not only associated with lower levels of pulmonary function but also with the occurrence of both acute respiratory illness and chronic respiratory symptoms in children.[1] Concern for the health of their children could be a strong incentive to encourage smoking parents to quit and nonsmokers not to start.

APPENDIX

Variables Used in Regression Analysis

1. Age (years)
2. Standing height (centimeters)
3. Weight (kilograms)
4. Chest measurement (centimeters)
5. Educational status of father (university: 263, secondary: 287, primary: 21)
6. Smoking quantity of the father during the child's lifetime (never: 346, less than 50 cigarettes/day × years: 69, 50- cigarettes/day × years: 50, 100- cigarettes/day × years: 57, 150- cigarettes/day × years: 16, 200- cigarettes/day × years: 33)
7. Smoking status of other individuals in the family (no: 538, yes: 33)
8. Use coal for cooking (no: 488, yes: 83)
9. Use gas for cooking (no: 84, yes: 487)
10. Average residential area per capita (square meters)
11. Presence of patient with chronic respiratory diseases in family (no: 501, yes: 70)
12. FVC (liter, considered when $FEV_{1.0}$, MMEF, and $FEF_{25-75\%}$ were analyzed)

REFERENCES

1. Weiss ST, Tager IB, Schenker M, Speizer FE: The health effects of involuntary smoking. Am Rev Respir Dis 1983; 128:933–942.
2. Wynder EL, Goodman MT: Smoking and lung cancer: some unresolved issues. Epidemiol Rev 1983; 5:177–207.
3. Johansson CR: Tobacco smoke in room air—an experimental investigation of odour perception and irritating effects. Build Serv Eng 1976; 43:254–262.
4. Schmeltz I, Hoffmann D, Wynder EL: The influence of tobacco smoke on indoor atmospheres. Prev Med 1975; 4:66–82.
5. Stedman RL: The chemical composition of tobacco and tobacco smoke. Chem Rev 1968; 68:153–207.
6. Weiss ST, Tager IB, Speizer FE, Rosner R: Persistent wheeze: its relationship to respiratory illness, cigarette smoking and level of pulmonary function in a population sample of children. Am Rev Respir Dis 1980; 122:697–707.
7. Tager IB, Weiss ST, Rosner B, Speizer FE: Effect of parental cigarette smoking on the pulmonary function in children. Am J Epidemiol 1979; 123:479–486.
8. Hasselblad V, Humble CG, Graham MG, Anderson HS: Lung function in children. Am Rev Respir Dis 1981; 123:479–485.
9. Lebowitz MD, Armet DB, Knudson R: The effect of passive smoking on pulmonary function on children. Environ Int 1982; 8:371–373.
10. Lu Bao-shen: The effect of air pollution on lung function in middle school children. J Inst Health (Chinese) 1981; 3:52–54.
11. Schilling RSF, Letai AD, Hirs ST, Schoenberg JB: Lung function, respiratory disease, and smoking in families. Am J Epidemiol 1977; 106:274–283.
12. Dodge R: The effects of indoor pollution on Arizona children. Arch Environ Health 1982; 37:151–153.
13. Speizer FE, Ferris BJ, Bishop YMM, Spengler J: Respiratory disease rates and pulmonary function in children associated with NO_2 exposure. Am Rev Respir Dis 1980; 121:3–10.
14. Lebowitz MD, Burrews B: Respiratory symptoms related to smoking habits of family adults. Chest 1976; 69:48–50.
15. Yang Rui-zhang, Tan Ying: The methods of normality test. J Harbin Med Univ (Chinese) 1983; 4:66–72.
16. Shigeoka JW: Pulmonary function testing. *In:* Rom WN (ed): Environmental & Occupational Medicaine. Boston: Little, Brown, 1982.
17. Cherniann RM (ed): Pulmonary Function Testing. Philadelphia: W. B. Saunders, 1977.
18. Grundmann E, Müller K-M, Winter KD: Passive smoking. (letter) Br Med J 1981; 282:1156–1157.
19. Ferris BG: Air pollution. *In:* Macklem PT, Permutt (eds): The Lung in the Transition between Health and Disease. New York: Marcel Dekker, 1978.
20. Colley JRT: Respiratory symptoms in children and parental smoking and phlegm production. Br Med J 1974; 2:201–204.
21. Smoking and Health: A report of the Surgeon General. DHEW Pub. No. 79-50066. Washington, DC: Govt Printing Office, 1979.